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NEW UTILITY PATENT APPLICATION**

**TITLE: ACCESS CONTROL UNIT AND METHOD FOR USE WITH
 SYNCHRONOUS DYNAMIC RANDOM ACCESS MEMORY DEVICE**

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ACCESS CONTROL UNIT AND METHOD FOR USE WITH SYNCHRONOUS DYNAMIC RANDOM ACCESS MEMORY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention:

5 This invention relates to computer memory technology, and more particularly, to an access control unit and method for use with an SDRAM (Synchronous Dynamic Random Access Memory) chip for controlling a burst transfer access operation on the SDRAM chip.

2. Description of Related Art:

 SDRAM (Synchronous Dynamic Random Access Memory) is an advanced type of
10 DRAM (Dynamic Random Access Memory), which is characterized by that the data access rate is synchronized with CPU's clock signal, allowing the CPU to retrieve data from SDRAM without latency so that the access speed is increased. An SDRAM device operates in two modes: interleaved mode or sequential mode.

 With the above-mentioned SDRAM characteristics, the required access control
15 circuitry for an SDRAM chip should be designed to comply with these requirements so as to be able to perform the data access operations.

 One drawback to conventional SDRAM access control units, however, is that the burst length in each burst transfer access operation is a fixed amount of data, such as 8 bits or 16 bits, and cannot be changed arbitrarily.

20 Still another drawback of conventional SDRAM access control units is that at the completion of each burst transfer access operation, a burst stop command or a precharge

interrupt method should be used to terminate the burst transfer access operation, which makes the required logic circuitry more complex in structure.

SUMMARY OF THE INVENTION

It is therefore an objective of this invention to provide an SDRAM access control
5 unit and method which allows the burst length in each burst transfer access operation to be changed arbitrarily.

It is another objective of this invention to provide an SDRAM access control unit and method which allows each burst transfer access operation to be terminated without having to use a burst stop command or a precharge-interrupt method so that the required
10 logic circuitry can be made less complex in structure than prior art.

The proposed access control unit and method is characterized by that the column-address strobe signal involved in each round of the burst-transfer access operation is continuously set at active state for a period of clock pulses equal in number to the specified burst length of the burst-transfer access operation, rather than just for a period of
15 one pulse. This feature allows external circuitry to arbitrarily change the burst length, and also allows no use of burst-stop command or a precharge-interrupt method to stop each round of the burst-transfer access operation, allowing the access control logic circuit architecture to be more simplified than the prior art.

BRIEF DESCRIPTION OF DRAWINGS

The invention can be more fully understood by reading the following detailed description of the preferred embodiments, with reference made to the accompanying drawings, wherein:

5 FIG. 1 is a schematic block diagram showing the system architecture of the SDRAM access control unit according to the invention;

FIG. 2 is a signal sequencing diagram showing the sequence of a number signals used by the SDRAM access control unit of the invention to perform a write operation on the SDRAM chip; and

10 FIG. 3 is a signal sequencing diagram showing the sequence of a number signals used by the SDRAM access control unit of the invention to perform a read operation on the SDRAM chip.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The SDRAM access control unit and method according to the invention is disclosed
15 in full details by way of preferred embodiments in the following with reference to the accompanying drawings.

FIG. 1 is a schematic block diagram showing the system architecture of the SDRAM access control unit according to the invention (as the part enclosed in the dotted box indicated by the reference numeral 100). As shown, in practical use, the SDRAM
20 access control unit of the invention 100 is coupled between an SDRAM chip 20 and a memory arbiter 10 connected to a plurality of data processing units 30, for the purpose of controlling the data flow between the memory arbiter 10 and the SDRAM chip 20,

including data write operations to the SDRAM chip 20 and data read operations from the SDRAM chip 20. The SDRAM chip 20 can be either a conventional SDRAM, an advanced DDR (Double Data Rate) SDRAM chip, or a memory chip having similar SDRAM characteristics.

5 The SDRAM access control unit of the invention 100 is interconnected with the memory arbiter 10 via a number of signal lines as follows:

(A1) *REQ*, which is used for the memory arbiter 10 to issue a write/read request to the SDRAM access control unit of the invention 100;

(A2) *ADDR*, which is used for the memory arbiter 10 to issue an address signal to
10 the SDRAM access control unit of the invention 100;

(A3) *LENGTH*, which is used for the memory arbiter 10 to issue a burst length signal to the SDRAM access control unit of the invention 100 to indicate of the length of data for each burst;

(A4) *MODE*, which is used for the memory arbiter 10 to issue a mode signal to the
15 SDRAM access control unit of the invention 100 to indicate whether the intended write/read operation is in interleaved mode or sequential mode;

(A5) *DATA_IN*, which is used for the SDRAM access control unit of the invention 100 to transfer retrieved data from the SDRAM chip 20 to the memory arbiter 10 that are requested by the memory arbiter 10;

20 (A6) *DATA_OUT*, which is used for the SDRAM access control unit of the invention 100 to receive the data from the SDRAM chip 20 that are intended to be written into the SDRAM chip 20;

(A7) *READY*, which is used for the SDRAM access control unit of the invention 100 to issue a ready signal to the memory arbiter 10;

(A8) *LAST_READY*, which is used for the SDRAM access control unit of the invention 100 to issue a last ready signal to the memory arbiter 10 to indicate that the last
5 write/read operation is readily completed.

On the other side, the SDRAM access control unit of the invention 100 is interconnected with the SDRAM chip 20 via a number of signal lines as follows:

(B1) *RAS-*, which is used for the SDRAM access control unit of the invention 100 to issue a row address strobe signal to the SDRAM chip 20;

10 (B2) *CAS-*, which is used for the SDRAM access control unit of the invention 100 to issue a column address strobe signal to the SDRAM chip 20;

(B3) *WE-*, which is used for the SDRAM access control unit of the invention 100 to issue a write enable signal to the SDRAM chip 20; wherein in this embodiment, for example, when *WE-* is at LOGIC-HIGH state, it indicates that write operation is intended;
15 and whereas when *WE-* is at LOGIC-LOW state, it indicates that read operation is intended

(B4) *ADDR*, which is used for the SDRAM access control unit of the invention 100 to issue an address signal to the SDRAM chip 20;

(B5) *DATA*, which is a bi-directional data line for the SDRAM access control unit of the invention 100 to transfer data to the SDRAM chip 20 during write operation, and for
20 the SDRAM chip 20 to transfer data to the SDRAM access control unit of the invention 100 during read operation;

(B6) *DQM*, which is used for the SDRAM access control unit of the invention 100 to issue a data mask signal to the SDRAM chip 20;

(B7) *CS*, which is used for the SDRAM access control unit of the invention 100 to issue a chip selection signal to the SDRAM chip 20;

(B8) *CKE*, which is used for the SDRAM access control unit of the invention 100 to issue a clock enable signal to the SDRAM chip 20.

5 The SDRAM access control unit of the invention 100 comprises: (a) an address mapping table 110; (b) an access control logic circuit 120; (c) a configuration register 130; (d) a column address control module 140; and (e) a finite state machine 150.

 The address mapping table 110 is used to receive the *REQ* and *ADDR* signals from the memory arbiter 10 and translate the received *ADDR* signal into corresponding SDRAM
10 addresses.

 The access control logic circuit 120 is interconnected with the memory arbiter 10 via the *MODE*, *LENGTH*, *DATA_OUT*, *DATA_IN*, *READY*, and *LAST_READY* signal lines, and is interconnected with the SDRAM chip 20 via the bi-directional *DATA* line, for controlling the data flow between the memory arbiter 10 and the SDRAM chip 20.

15 The configuration register 130 is used to register the configuration parameters of the clocking of various signals of the SDRAM chip 20 to allow the access control logic circuit 120 and the finite state machine 150 to perform access operations to the SDRAM chip 20 accordingly.

 The column address control module 140 is coupled to the finite state machine 150
20 for use to control the row addresses during each access operation under interleaved mode or sequential mode.

 The finite state machine 150 is used to generate a corresponding set of access control signals [*RAS-*, *CAS-*, *WE-*, *ADDR*, *DQM*, *CS*, *CKE*] under control by the address

mapping table 110, the access control logic circuit 120, and the column address control module 140 to control the access operations to the SDRAM chip 20.

The SDRAM access control unit of the invention 100 is characterized by that the duration of the column address strobe signal *CAS-* is set to be equal to the total time length
5 of each burst transfer access operation. For example, if each burst transfer access operation involves the transfer of 4 bits of data, then the *CAS-* signal line is set at enabled state (assume LOGIC-LOW state) all the time during the burst transfer access operation.

FIG. 2 and FIG. 3 are signal sequencing diagrams respectively showing the sequence of a number signals used by the SDRAM access control unit of the invention 100
10 to perform a write operation and a read operation on the SDRAM chip 20. In this embodiment, for example, assume each burst transfer access operation involves the transfer of 4 bits of data.

Referring to FIG. 2 together with FIG. 1, when a write operation is requested, then during the first clock pulse *TW1*, the finite state machine 150 first sets the *RAS-* signal line
15 to LOGIC-LOW state and then issues an address from the *ADDR* signal line.

During the second clock pulse *TW2*, the finite state machine 150 resets the *RAS-* signal line to LOGIC-HIGH state.

During the third clock pulse *TW3*, the finite state machine 150 sets the *CAS-* signal line to LOGIC-LOW state and meanwhile sets the *WE-* signal line to LOGIC-LOW state.
20 At the same time, the finite state machine 150 outputs the first bit of data from the bi-directional *DATA* line and issues the corresponding address from the *ADDR* signal line. This causes the first bit of data to be stored in the specified address in the SDRAM chip 20.

During the fourth clock pulse *TW4*, the *CAS-* signal line is continuously maintained at LOGIC-LOW state while the *WE-* signal line is also continuously maintained at LOGIC-LOW state. During this period, the finite state machine 150 outputs the second bit of data from the bi-directional *DATA* line and issues the corresponding address from the
5 *ADDR* signal line. This causes the second bit of data to be stored in the specified address in the SDRAM chip 20.

During the fifth clock pulse *TW5*, the *CAS-* signal line is continuously maintained at LOGIC-LOW state while the *WE-* signal line is also continuously maintained at LOGIC-LOW state. During this period, the finite state machine 150 outputs the third bit of
10 data from the bi-directional *DATA* line and issues the corresponding address from the *ADDR* signal line. This causes the third bit of data to be stored in the specified address in the SDRAM chip 20.

During the sixth clock pulse *TW6*, the *CAS-* signal line is continuously maintained at LOGIC-LOW state while the *WE-* signal line is also continuously maintained at
15 LOGIC-LOW state. During this period, the finite state machine 150 outputs the fourth bit of data from the bi-directional *DATA* line and issues the corresponding address from the *ADDR* signal line. This causes the fourth bit of data to be stored in the specified address in the SDRAM chip 20.

During the seventh clock pulse *TW7*, the *CAS-* signal line is reset to LOGIC-HIGH
20 state while the *WE-* signal line is also reset to LOGIC-HIGH state. This completes the burst transfer access operation for 4 bits of data.

Referring to FIG. 3 together with FIG. 1, when a read operation is requested, then during the first clock pulse *TR1*, the finite state machine 150 first sets the *RAS-* signal line to LOGIC-LOW state and then issues a row address from the *ADDR* signal line.

During the second clock pulse *TR2*, the finite state machine 150 resets the *RAS-* signal line to LOGIC-HIGH state.

During the third clock pulse *TR3*, the finite state machine 150 sets the *CAS-* signal line to LOGIC-LOW state. Since the current access operation is a read operation, the *WE-* signal line is maintained at LOGIC-HIGH state. At the same time, the finite state machine 150 outputs the column address where the requested first bit of data is stored in the SDRAM chip 20. It is to be noted that the latency period is 3 clock pulses, and therefore, the SDRAM chip 20 will output the requested first bit of data until *TR6*.

During the fourth clock pulse *TR4*, the *CAS-* signal line is continuously maintained at LOGIC-LOW state while the *WE-* signal line is continuously maintained at LOGIC-HIGH state. At the same time, the finite state machine 150 outputs the column address where the requested second bit of data is stored in the SDRAM chip 20. It is to be noted that the latency period is 3 clock pulses, and therefore, the SDRAM chip 20 will output the requested second bit of data until *TR7*.

During the fifth clock pulse *TR5*, the *CAS-* signal line is continuously maintained at LOGIC-LOW state while the *WE-* signal line is continuously maintained at LOGIC-HIGH state. At the same time, the finite state machine 150 outputs the column address where the requested third bit of data is stored in the SDRAM chip 20. It is to be noted that the latency period is 3 clock pulses, and therefore, the SDRAM chip 20 will output the requested third bit of data until *TR8*.

During the sixth clock pulse *TR6*, the *CAS-* signal line is continuously maintained at LOGIC-LOW state while the *WE-* signal line is continuously maintained at LOGIC-HIGH state. At the same time, the finite state machine 150 outputs the column address where the requested fourth bit of data is stored in the SDRAM chip 20. It is to be noted that the
5 latency period is 3 clock pulses, and therefore, the SDRAM chip 20 will output the requested fourth bit of data until *TR9*. During this clock pulse *TR6*, the latency period for the requested first bit of data is reached , and therefore, the SDRAM chip 20 outputs the requested first bit of data from the bi-directional *DATA* line.

During the seventh clock pulse *TR7*, since addressing is completed, the *CAS-* signal
10 line is reset to LOGIC-HIGH state while the *WE-* signal line is still maintained at its normal LOGIC-HIGH state. During this clock pulse *TR7*, the latency period for the requested second bit of data is reached , and therefore, the SDRAM chip 20 outputs the requested second bit of data from the bi-directional *DATA* line.

During the eighth clock pulse *TR8*, the latency period for the requested third bit of
15 data is reached, and therefore, the SDRAM chip 20 outputs the requested third bit of data from the bi-directional *DATA* line.

During the ninth clock pulse *TR9*, the latency period for the requested fourth bit of data is reached, and therefore, the SDRAM chip 20 outputs the requested fourth bit of data from the bi-directional *DATA* line. This completes the burst transfer access operation for 4
20 bits of data.

In conclusion, the invention provides an SDRAM access control unit and method, which is characterized by that characterized by that the duration of the column address strobe signal *CAS-* is set to be equal to the total time length of each burst transfer access

operation, and not just equal to one clock pulse as in the case of prior art. This feature allows the SDRAM access control unit of the invention to freely adjust the burst length (i.e., number of bits) in each burst transfer access operation, without having to use a burst stop command or a precharge-interrupt method as in the case of prior art. This benefit
5 allows the logic circuit structure to be more simplified than prior art. The invention is therefore more advantageous to use than the prior art.

The invention has been described using exemplary preferred embodiments. However, it is to be understood that the scope of the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and
10 similar arrangements. The scope of the claims, therefore, should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.